Environmental Management Plan

BGC Voyager II Quarry
Blast and Vibration Management Plan

Voyager II Quarry, The Lakes, Shire of Northam.

BGC (Australia) Pty Ltd
18 Mount Street
Perth WA 6000

Revision September 2018
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1 Element/issue

1.1 Introduction

This document presents the Blast and Vibration Management Plan for the BGC Voyager II Quarry as required under Condition 18 of the Minister for the Environment Statement Number 706, (Condition 706:M18) dated 16 December 2005. A key objective of this Blast and Vibration Management Plan is to present the framework under which BGC Quarries intend to manage blasting activities to satisfy regulatory requirements.

Voyager II Quarry is located within the Shire of Northam on the Great Southern Highway at The Lakes, on Lot 14 Horton Road, Avon Location 1881. Figure 1 below shows BGC Voyager II Quarry has been zoned an “Extraction Area” that is located within a wider area designated “Agricultural”.

1.2 EPA Bulletin 1169

EPA Bulletin 1169 states that BGC Quarries had recognised the importance of blast vibration and air overpressure and had commissioned a number of studies to assess their impact. These studies including an array of modelling exercises supported BGC assertions that airblast overpressure and ground vibration associated with blasting at the proposed quarry would not exceed the relevant statutory limits and would not cause damage to adjacent residences. The studies also provided information on appropriate management measures to be implemented prior to, and during each blast, to ensure that all statutory limits are adhered to.

Whilst the EPA recognised that the proponent has proposed a large number of management actions to minimise the risks posed by operational noise and blasting, the EPA considered that there is a need for full confidence that the impacts of operational noise and blasting will be managed in a way that protects the amenity of the surrounding community. As a consequence Condition 17 (Ground Vibration) and Condition 18 (Blast and Vibration Management Plan) were included within Statement 706.

1.3 EPA Bulletin 1466

Consequent to an application by the proponent under Section 46 of the Environmental Protection Act 1986, the EPA provided the following advice: “The EPA considers Condition 18 of Ministerial Statement 706, the provisions of the Mines Safety and Inspection Act 1994 and Part V of the EP Act, are sufficient to manage the potential impacts of Blasting at the Voyager II Quarry (Bulletin 1466). (Therefore) the EPA recommends the deletion of Condition 17”. Consequently, Ministerial Statement 934 arising from the recommendations of Bulletin 1466 deleted Condition 17.
Figure 1: Location of Voyager II Quarry (from Government of Western Australia\(^3\))

1.4 **Ministerial Statement 706**

Ministerial Statement 706 was published on 16 December 2005. Conditions 16, 17 and 18 of Statement 706 were relevant to the requirements of the Blast and Vibration Measurement Plan. As stated above, Condition 17 was deleted under Statement 934.

Condition 16 refers to operational noise and states:

16-1 Prior to any excavation works below five metres depth from the surface, the proponent shall prepare an Operational Noise Management Programme to ensure that all noise from the quarry is measured in accordance with Part 3 of the Environmental Protection (Noise) Regulations 1997.

16-2 The proponent shall implement the Operational Noise Measurement Programme required by condition 16-1 and any subsequent updates as required by condition 16-3.

16-3 The proponent shall review and update the Operational Noise Programme required by condition 16-1 annually.

16-4 The proponent shall utilise that form of safety alarm on items of equipment which produces the least noise whilst complying with all statutory requirements, particularly safety requirements.

16-5 The proponent shall report any exceedances of the Environmental Protection (Noise) Regulations 1997, aside from those that meet the requirements of condition 15-6, to the Department of Environment within 24 hours of exceedances being recorded.

16-6 Upon identifying any exceedances of the Environmental Protection (Noise) Regulations 1997, aside from those that meet the requirements of condition 15-6, the proponent shall provide a report, within seven days of exceedances being recorded, to the Department of Environment on the source/reason for the exceedance, remedial actions undertaken or intended to prevent further such exceedances.

16-7 The proponent shall make the Noise Measurement Programme required by condition 16-1 publicly available.

Condition 18 requires that BGC Quarries develop a Blast and Vibration Management Plan, and states:

18-1 Prior to clearing the vegetation or excavation of soil or rock, whichever is the sooner, the proponent shall prepare a Blast and Vibration Management Plan to the requirements of the Minister for the Environment.

The objective of this Plan is to manage blasting activities to prevent unacceptable impacts on the amenity of nearby residents.

The Plan shall:

1. detail blast management and monitoring procedures at the quarry; and
2. identify communication procedures with local residents with respect to blasting

18-2 The proponent shall implement the Blast and Vibration Management Plan required by condition 18-1 and any subsequent updates as required by condition 18-3.

18-3 The proponent shall review and update the Blast and Vibration Management Plan required by condition 18-1 annually to include the outcomes of consultation with the owners and residents of land surrounding the project area.

18-4 The proponent shall make the Blast and Vibration Management Plan required by condition 18-1 publicly available.
1.5 Legal Framework

The proposal for the relocation of the Voyager II Quarry was assessed under Part IV of the Environmental Protection Act 1986. In addition to Ministerial approval of the proposal (Statement 706), BGC Quarries is required to comply with a range of statutory requirements. Legislation that relates to the aspects of Condition 18 is summarised in Table 1 below. Local legislation and other documents that are of relevance to blasting at BGC Voyager II Quarry extension are summarised in below.

Table 1: Regulatory Requirements

<table>
<thead>
<tr>
<th>Title</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous Goods Safety (Explosives) Regulations 2007.</td>
<td>Part 9 — Storage and keeping of explosives</td>
</tr>
<tr>
<td></td>
<td>Part 12 — Use of explosives</td>
</tr>
<tr>
<td></td>
<td>Division 4 — Using Explosives to blast etc</td>
</tr>
<tr>
<td></td>
<td>Regulation 130 – Blast plans to be consistent with AS 2187.2</td>
</tr>
<tr>
<td></td>
<td>(Appendix A Section A2 &amp; Appendix K, Section K6).</td>
</tr>
<tr>
<td>Mines Safety and Inspection Act 1994</td>
<td>Part 2 — General duties relating to occupational safety and health</td>
</tr>
<tr>
<td></td>
<td>Division 2 — General duties</td>
</tr>
<tr>
<td></td>
<td>Section 11 Reporting of dangerous situations or occurrences</td>
</tr>
<tr>
<td></td>
<td>Part 3 — Administration of Act</td>
</tr>
<tr>
<td></td>
<td>Division 2 — Inspections</td>
</tr>
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<td></td>
<td>Section 21 Powers of inspectors</td>
</tr>
<tr>
<td></td>
<td>Part 10 — Final provisions</td>
</tr>
<tr>
<td>Mines Safety and Inspection Regulations 1995</td>
<td>Part 8 — Explosives</td>
</tr>
<tr>
<td></td>
<td>Regulation 8.12. Users of explosives or blasting agents must be Competent</td>
</tr>
<tr>
<td></td>
<td>Regulation 8.26. Firing warnings — surface mining operations</td>
</tr>
<tr>
<td></td>
<td>Regulation 8.28. Firing times — surface mining operations</td>
</tr>
<tr>
<td></td>
<td>Regulation 8.30. Fly rock surface mining operations</td>
</tr>
<tr>
<td>Environmental Protection Act 1986</td>
<td>Ministerial Statement 706 was issued under Part IV of the Act. Section 44 of</td>
</tr>
<tr>
<td></td>
<td>the Environmental Protection Act 1986 requires the EPA to report to the</td>
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<td></td>
<td>Minister for the Environment on the environmental factors relevant to the</td>
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<td></td>
<td>project and on the conditions and procedures to which the proposal should be</td>
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<tr>
<td></td>
<td>subject, if implemented. In addition, the EPA may make recommendations as</td>
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<td>it sees fit. Under Part V of the Act, BGC was issued with a Works Approval</td>
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<tr>
<td></td>
<td>and Operating Licence.</td>
</tr>
<tr>
<td>Environmental Protection (Noise) Regulations 1997</td>
<td>Part 2 — Allowable noise emissions: Regulation 11 Airblast levels due to</td>
</tr>
<tr>
<td></td>
<td>blasting</td>
</tr>
<tr>
<td></td>
<td>Part 2 — Allowable noise emissions: Regulation 17 Where standard cannot</td>
</tr>
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<td></td>
<td>be reasonably met.</td>
</tr>
<tr>
<td></td>
<td>Part 3 – Noise measurement: Regulation 21 Measurement of airblast levels</td>
</tr>
<tr>
<td></td>
<td>Schedule 4 Rules for Sound Measuring Equipment. 5 Instrument used for</td>
</tr>
<tr>
<td></td>
<td>measurement of airblast levels</td>
</tr>
<tr>
<td>Australian Standard AS2187.2 - 2006</td>
<td>Appendix A2. Records required for the design, planning and outcome impacts on</td>
</tr>
<tr>
<td></td>
<td>the surrounding environment. Appendix J: Table J4.(5A) – Ground vibration</td>
</tr>
<tr>
<td></td>
<td>limits for human comfort chosen by some regulatory authorities. Appendix K,</td>
</tr>
<tr>
<td></td>
<td>Section K6 Demolition Blast Plan.</td>
</tr>
</tbody>
</table>
### Table 2: Other Relevant Documents

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Title</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Environmental Regulation</td>
<td>Draft Guideline: <em>Preparing Environmental Management Plans</em></td>
<td>This document has been prepared in compliance with the draft document.</td>
</tr>
<tr>
<td>Explosives—Storage and use</td>
<td><em>AS 2187.2—2006 Explosives—Storage and use Part 2: Use of explosives</em></td>
<td>Provides information with respect to blasting and blast monitoring.</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Geotechnical Considerations In Open Pit Mines Guideline, Department of Minerals and Energy</td>
<td>Provides some guidance with respect to the implementation of <em>Mines Safety and Inspection Regulations 1995</em> in the context of blasting.</td>
</tr>
<tr>
<td>Local Planning</td>
<td>Shire Of Northam Town Planning Scheme No.3 District Zoning Scheme Version 1, O’Brien Planning Consultants, M J Lundstrom Pty Ltd &amp; Planning Enterprises. Original Town Planning Scheme Gazetted Date: 20 May 2005</td>
<td>Describes Local Planning Strategy and requires Environmental conditions to be incorporated into a Scheme or an amendment to a Scheme following assessment under the Environmental Protection Act 1986.</td>
</tr>
</tbody>
</table>
2 Description of the Project

BGC operates Voyager II, on the Great Southern Highway, The Lakes, Shire of Northam. This site is approximately 16 kilometres east of the Town of Mundaring and 47 kilometres southwest of the Town of Northam located on the Great Southern Highway, Western Australia. Figure 2 below indicates the boundaries as approved under Statement 706 and status of the quarry concurrent with the 2014 review of this Blast and Vibration Management Plan.

Voyager II Quarry was commissioned with the issuing of Operating Licence L8415 under Part V of the EP Act on 24th September 2010. BGC had previously operated the Voyager I Quarry since 1990; this quarry was located on private land immediately to the east of Voyager II and was decommissioned at the time of the commissioning of Voyager II Quarry. The decommissioned Voyager I Quarry can be seen on the east of and adjacent to the boundary of Voyager II in Figure 2 below.

Over time, the Voyager II proposal will involve development and operation of a quarry incorporating excavation of approximately 16 million tonnes of hard rock, approximately 2 million tonnes of gravel and approximately 12 million tonnes of clay from the quarry footprint. This will allow for approximately 60 million tonnes of granite to be excavated from the site over a 50 year period. The quarry footprint itself covers an area of approximately 59 hectares.

Conventional drilling and blasting, loading and hauling, crushing and screening methods are employed.

The project’s development will occur in six stages over the life of the mine, where stage 1 and 2 were initially developed to provide room for the new below-ground level facilities and infrastructure. Stages 3 and 4 immediately to the north of the processing area have been quarried since 2010 and subsequent stages will be developed as the need to access granite resources arises. The staged approach ensures that excavation of the topsoil and subsoil (gravel and clay) will only occur on five occasions during the life of the mine, thereby minimising the impacts of preparing each stage at any one time. All infrastructure, crushing and screening plants are housed below ground level, and the site has been surrounded by a buffer of visual and noise limiting bunds that have been rehabilitated with trees and shrubs.
Figure 2: Layout of Existing Voyager II Operations

Surveyed boundaries are indicated in red. The surveyed point indicated in yellow was due to an error in Statement 706 locating corner point “E”. The decommissioned Voyager I Quarry can be seen on the east of Voyager II (aerial photograph from LandGate 2013).
2.1 Blast Practices

At the BGC Voyager II Quarry, blasting is carried out only on weekdays between 0700 hours and 1800 hours.

Blast practices to date have resulted in compliance with respect to both blast-induced vibration and overpressure.

The BGC Voyager II Quarry has a drill and blast manual that is periodically updated to take account of legislation, Codes of Practice, site conditions, contractual requirements and site specific experience. The manual provides a set of procedures for the safe handling of explosives at the site and also guidance with respect to blast designs that have been proven appropriate to meet the quarry objectives.

To effectively manage the drill and blast process, BGC Quarries engages independent specialist contractors to:

1. Carryout blast design, implement blast designs;
2. Drill blast holes to a designed pattern; and
3. Conduct vibration and blast over-pressure monitoring.

Contractors are appointed to optimise the drill and blast operations and to ensure that compliance criteria are met. Under the contractual arrangements the Quarry Manager has approved an employee of the contractor who is a designated as the shotfirer. The shotfirer is appropriately trained and certified, and is responsible for the drill and blast processes.

Specially prepared stemming material is used by BGC Voyager II Quarry to contain the energy of the blast and minimise the potential for flyrock.

As a part of the blasting procedures the Quarry Manager or his appointee is required to advise local residents prior to a blast to confirm the intended blast schedule. Residents and other interested parties are advised either by telephone or email, and the preferred method of communication is defined by the party in question.

If weather conditions are determined to be unfavourable a blast may be delayed to the next day in which case interested parties are so advised. Unfavourable weather conditions may include low cloud cover, temperature inversion, wind direction towards sensitive premises. When a shot is allowed to sleep the blast area is secured.

Blast patterns are also subject to safety issues; a blast may sleep from Monday through to Friday but for safety reasons shots may not sleep over a weekend. Also, a blast may not be delayed if an electrical storm is predicted.
2.1.1 Compliance Requirements

Condition 706:M18 is reproduced in Section 1.4 above; the objective of the Blast and Vibration Plan being “to manage blasting activities to prevent unacceptable impacts on the amenity of nearby residents”.

Blast-induced ground vibrations are measured to ensure compliance with Australian Standard AS2187.2-2006 (see Tables 1, 5 and 6) as required by the Dangerous Goods Safety (Explosives) Regulations (2007).

In the case of air overpressure, DER licence condition require Voyager II Quarry to measure blast air overpressure and report any exceedances of the Environment Protection (Noise) Regulations 1997 Sub-regulations (3) to (5) of Regulation 11 (as amended Regulations 2013) are reproduced below.

Environment Protection (Noise) Regulations 1997 - Regulation 11

(3) No airblast level resulting from blasting on any premises or public place, when received at any other premises, may exceed —

(a) 120 dB L_{peak} between 0700 hours and 1800 hours on Monday to Saturday inclusive; or

(b) 115 dB L_{peak} between 0700 hours and 1800 hours on a Sunday or public holiday.

(4) Notwithstanding sub-regulation (3), airblast levels for 9 in any 10 consecutive blasts (regardless of the interval between each blast), when received at any other premises, must not exceed —

(a) 115 dB L_{peak} between 0700 hours and 1800 hours on Monday to Saturday inclusive; or

(b) 110 dB L_{peak} between 0700 hours and 1800 hours on a Sunday or public holiday.

(5) No airblast level resulting from blasting on any premises or public place, when received at any other premises, may exceed —

(a) 90 dB L_{peak} outside the periods between 0700 hours and 1800 hours on any day except where that blasting is carried out in accordance with regulation 8.28(4) of the Mines Safety and Inspection Regulations 1995; or

(b) the levels specified in sub-regulations (3) and (4) outside the periods between 0700 hours and 1800 hours, as appropriate for the time when it was intended that the blast be fired, if the exception in paragraph (a) applies.
3 Potential Impacts

During 2004 BGC commissioned an assessment of blast impact\(^6\). This document reviewed available monitoring records and presented a discussion on the potential for blast induced (vibration and air overpressure) damage to structures. A summary of these discussions is given below.

3.1 Blast Vibration

The recommended AS2187.2-2006 blast vibration limits for cosmetic damage to structures is reproduced in Table 3 below. The expected maximum blast induced vibration levels at residential properties adjacent to the BGC Voyager II Quarry are substantially lower than the recommended maximum limits to prevent damage to a structure.

Table 3: AS2187.2-2006 Ground Vibration Limits for Cosmetic Damage

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of blasting operations</th>
<th>Peak component particle velocity (mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other structures or architectural elements that include masonry,</td>
<td>All blasting</td>
<td>Type of Building</td>
</tr>
<tr>
<td>plaster and plasterboard in their construction</td>
<td></td>
<td>4-15Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above</td>
</tr>
<tr>
<td>Unoccupied structures of reinforced concrete or steel construction</td>
<td>All blasting</td>
<td>100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply</td>
</tr>
<tr>
<td>Service structures, such as pipelines, powerlines and cables</td>
<td>All blasting</td>
<td>Limit to be determined by structural design methodology</td>
</tr>
</tbody>
</table>

Compliance with legislative limits or Standards does not necessarily ensure residents will not perceive the vibration from quarry activities. Humans are very sensitive to vibration. They are, however, poorly equipped to distinguish between different intensity or disturbance. Human perception, and hence personal amenity, is difficult to precisely define in view of the fact that a person's perception and response will vary according to the nature of vibration (duration, amplitude, frequency, and frequency of occurrence), health, state of mind, temperament, and physical attitude of individuals. Consequently, vibration or overpressure on one occasion may be acceptable to a nearby person, although a disturbance at a similar level on another day may be classified as offensive by the same individual. Experience gained from the environmental monitoring of blasting activities has shown that when ground vibration routinely exceeds the threshold of perception (around 1 mm/s), the possibility of complaints arises. Given that short duration vibrations of less than 1 mm/s are generally considered imperceptible, complaints under these circumstances are more commonly related to alternative sources of annoyance, such as overpressure or noise.

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The recommended *Australian Standard AS2187.2-2006* blast vibration limits for human comfort are presented in Table 4.4 below.

**Table 4: Recommended AS2187.2-2006 Ground Vibration Limits For Human Comfort**

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of blasting operations</th>
<th>Peak component particle velocity (mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive site*</td>
<td>Operations lasting longer than 12 months or more than 20 blasts</td>
<td>5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply</td>
</tr>
<tr>
<td>Sensitive site*</td>
<td>Operations lasting for less than 12 months or less than 20 blasts</td>
<td>10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply</td>
</tr>
<tr>
<td>Occupied non-sensitive sites, such as factories and commercial premises</td>
<td>All blasting</td>
<td>25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer’s specifications or levels that can be shown to adversely effect the equipment operation</td>
</tr>
</tbody>
</table>

*A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

NOTE: The recommendations are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

### 3.1.1 Management of Blast Vibration

The principal design method for managing blast induced vibration at the Voyager II Quarry is by controlling the maximum instantaneous charge weight (MIC).

During 2004 and 2005 BGC monitored a series of blasts to establish site specific vibration attenuation characteristics. The site specific vibration attenuation equation derived from interpretation and analysis of the results of monitoring

\[
PPV = 473 \times \frac{D}{\sqrt{Wt}}^{[-0.367]}
\]

Where,

- \( PPV \) = instantaneous resultant of the three orthogonal components of peak particle velocity of ground motion (mm/s)
- \( Wt \) = weight of the explosive per delay (kg)
- \( D \) = distance between blast holes and the locality of receiver (m)
- \( K, n \) = site specific parameters relating to local conditions and strength

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The calculated attenuation of vibration, using the site specific equation given above, is shown graphically in Figure 3 below. This Figure also shows the attenuation that is predicted using the average attenuation relationship quoted in AS 2187.2 (2006). Consideration of Figure 3 shows that for scaled distances of greater than about 41 (equivalent to a distance of about 500m with a charge weight of 150 kg) the site specific vibration equation will predict a slightly greater level of vibration than the equation given in AS 2187.2 (2006). The site specific vibration attenuation equation is therefore slightly more conservative (i.e. predicts a greater level of vibration), under the anticipated circumstances, than the average attenuation equation given in AS 2187.2 (2006). The closest sensitive structure to blasting is approximately 560m.

![Figure 3: BGC Voyager II Quarry Site Specific Vibration Attenuation](image)

### 3.2 Blast Overpressure

#### Regulatory Requirement

The USBM (Siskind et.al.\(^3\)) have carried out extensive studies into the impact of air overpressure, and concluded that a level of 133 dBL (measured with a microphone with 2 Hz cut-off) can be regarded as incapable of causing damage (< 1% probability of even superficial damage) to the typical residential structures studied. The USBM add that the safe air overpressure levels are still high enough to produce secondary vibration effects (rattling of windows etc.). Complaints about rattling are observed to become more common when air overpressure levels exceed approximately 120dBL. Siskind et al have observed that up to 10% of homes will exhibit rattling once overpressure levels reach 134dBL.

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Reasons for limiting air overpressure can be related to concern for structural integrity, concern over human safety, or a concern over human annoyance. It is generally recognised that the potential for overpressure from normal rock blasting activities to inflict structural damage is very limited. It can be stated that the onset of structural damage from air overpressure is the cracking of glass windows. If windows have not cracked, the likelihood of structural damage is extremely remote.

Air overpressure levels less than 115 dBL rarely invoke complaints given that these levels are commonly exceeded by naturally occurring events such as wind. The perception of high overpressure levels is generally through the rattling of loosely fitting windows, often giving the misconception to the resident that the building has been subjected to very high levels of ground vibration.

The levels of air overpressure, that are expected to be generated by blast activities at the BGC Voyager II Quarry, are extremely unlikely to cause structural damage to adjacent residences that are approximately 560m from the quarry.

3.3 Flyrock

The management of flyrock is addressed through the provisions of the *Mines Safety and Inspection Regulations 1995* administered by the Department of Minerals & Petroleum, as well as via the Local Government Authority’s Extractive Industries Licence.

Extreme flyrock is usually considered to emanate from the collars of blast holes that had received inadequate stemming. Flyrock from this source is considered likely to travel in any direction from the hole. Other sources of potential flyrock include loose debris at the surface of the blast and also debris from the free face. It should be noted that flyrock originating as loose debris or from the free face would have a very low potential of travelling distances as far as 100 m from the source.

BGC Quarries incorporate a number of procedures to minimise the risks of flyrock, and to manage the potential for flyrock. These include attention to the detail of methods and practices of blast hole stemming. To verify the flyrock management procedures, a video record of each blast is made. This record allows the performance of the shot to be analysed. If excessive flyrock is identified then design changes would be made to reduce flyrock potential – this is a process of continual improvement, characteristic of all BGC Quarries operations. Detailed blast records are made and retained by BGC. This will help to keep the blasting experience on site and allow new personnel to access the “corporate memory”

With the blast design measures (stemming height and material) that are used at the BGC Voyager II Quarry there is a extremely low probability that debris could be thrown the maximum theoretical extreme range.
4 Performance Indicators/Criteria

The performance indicators and criteria that will be used to track progress in achieving objectives and targets are summarised in Table 5 and Table 6 below.

**Table 5: Indicators Used To Track Progress In Achieving Vibration Threshold Limits**

<table>
<thead>
<tr>
<th>Target</th>
<th>Performance Indicator</th>
<th>Criteria</th>
<th>Requirement</th>
<th>Means of Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PPV&lt;10mm/s at Sensitive Sites</td>
<td>Notification of Blast Schedule</td>
<td>BGC Voyager II Quarry Documented Drill and Blast Procedures</td>
<td>All interested parties to be notified prior to each blast. Notification register to be maintained.</td>
<td>Local residents are advised of blast schedule as per notified method of communication.</td>
</tr>
<tr>
<td>2. PPV&lt;5mm/s for at least 9 out of 10 blasts at Sensitive Sites</td>
<td>Monitoring</td>
<td>AS2187.2-2006</td>
<td>Record results of monitoring at a minimum of 2 locations for each blast.</td>
<td>Blast Monitoring Record. Annual Reporting of the monitoring outcomes to EPA.</td>
</tr>
<tr>
<td>Blast Record</td>
<td>Blast Record</td>
<td>BGC Voyager II Quarry Documented Drill and Blast Procedures and AS2187.2-2006</td>
<td>Complete blast record to be maintained for each blast. Record to be stored to allow easy access</td>
<td>Blast Monitoring Record is available for inspection by monitoring authorities.</td>
</tr>
<tr>
<td>Complaints register</td>
<td>Complaints register</td>
<td>BGC Voyager II Quarry Documented Drill and Blast Procedures</td>
<td>Maintain a register and address complaints in a timely manner.</td>
<td>Annual Reporting of the monitoring outcomes to EPA.</td>
</tr>
</tbody>
</table>

**Table 6: Used To Track Progress In Achieving Blast Overpressure Threshold Limits**

<table>
<thead>
<tr>
<th>Target</th>
<th>Performance Indicator</th>
<th>Criteria</th>
<th>Requirement</th>
<th>Means of Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overpressure &lt;125 dB L at Sensitive Sites</td>
<td>Notification of Blast Schedule</td>
<td>BGC Voyager II Quarry Documented Drill and Blast Procedures</td>
<td>All interested parties to be notified prior to each blast. Notification register to be maintained.</td>
<td>Local residents are advised of blast schedule as per notified method of communication.</td>
</tr>
<tr>
<td>2. Overpressure &lt;120 dB L for at least 9 out of 10 blasts at Sensitive Sites</td>
<td>Monitoring</td>
<td>Environmental Protection (Noise) Regulations 1997</td>
<td>Record results of monitoring at a minimum of 2 locations for each blast.</td>
<td>Blast Monitoring Record. Annual Reporting of the monitoring outcomes to EPA.</td>
</tr>
<tr>
<td>Blast Record</td>
<td>Blast Record</td>
<td>BGC Voyager II Quarry Documented Drill and Blast Procedures and AS2187.2-2006</td>
<td>Complete blast record to be maintained for each blast. Record to be stored to allow easy access</td>
<td>Blast Monitoring Record is available for inspection by monitoring authorities.</td>
</tr>
<tr>
<td>Non-compliance</td>
<td>Non-compliance</td>
<td>Department of Environmental Regulation</td>
<td>Notify the Department of Environmental Regulation within six hours and submit a report on the incident within 7 days.</td>
<td>Blast monitoring record. Annual Reporting of the monitoring outcomes to EPA.</td>
</tr>
<tr>
<td>Complaints register</td>
<td>Complaints register</td>
<td>Department of Environmental Regulation</td>
<td>Maintain a register and address complaints in a timely manner.</td>
<td>Annual Reporting of the monitoring outcomes to EPA.</td>
</tr>
</tbody>
</table>
Table 7: Drill and Blast Responsibilities to Meet Environmental Objectives

<table>
<thead>
<tr>
<th>Entity</th>
<th>Environmental Objective</th>
<th>Responsibility to Meet Environmental Objectives</th>
</tr>
</thead>
</table>
| Quarry Manager           | Minimise Blast induced Overpressure and Vibration to comply with the Australian Standard | Overall Quarry Planning and Scheduling.  
                            |                                                                                         | Overall Management of Drill and Blast Processes.  
                            |                                                                                         | Appointment of shotfirer with appropriate experience and qualifications.  
                            |                                                                                         | Developing and Maintaining the Blast and Vibration Management Plan.  
                            |                                                                                         | Developing and maintaining Voyager II Quarry drill and blast procedures.  
                            |                                                                                         | Advising interested parties of blast schedule.  
                            |                                                                                         | Review of the blast and blast monitoring results.  
                            |                                                                                         | Responding to complaints.  
                            |                                                                                         | Reporting non compliance to EPA. |
| Shotfirer                |                                                                                        | Implementation of drill and blast procedures.  
                            |                                                                                         | Implementation of specific blast design.  
                            |                                                                                         | Co-ordination of blast hole and free face survey.  
                            |                                                                                         | Co-ordination of drilling and blasting contractors.  
                            |                                                                                         | Co-ordination of monitoring at a minimum of 2 sensitive sites.  
                            |                                                                                         | Maintaining blast records.  
                            |                                                                                         | Reporting of monitoring results to Quarry Manager.  
                            |                                                                                         | Reporting unsafe or unusual practices to Quarry Manager. |
| Specialist Blast Contractor |                                                                                     | Blast design.  
                            |                                                                                         | Preparation of blast design records.  
                            |                                                                                         | Implementation of blast design.  
                            |                                                                                         | Blast survey (face and down-hole).  
                            |                                                                                         | QA/QC of blast.  
                            |                                                                                         | Supply of appropriate explosives and accessories.  
                            |                                                                                         | Loading of blast holes.  
                            |                                                                                         | Monitoring (vibration, overpressure, video).  
                            |                                                                                         | Maintain and report explosive and accessory usage.  
                            |                                                                                         | Provide specialist advice at request of Quarry Manager |
| Drilling Contractor      |                                                                                        | Drill blast holes in accordance with design requirements, and within the required tolerances. |
5 Monitoring

Vibration and air overpressure are monitored for all blasts that are fired at the Voyager II Quarry. Blast air overpressure and vibration monitoring is carried out by the specialist blasting contractor appointed and managed by BGC Quarries.

5.1.1 Monitoring Location

As monitoring stations are not located within Voyager II premises, monitors are set up at monitoring stations immediately prior to and then removed immediately after each blast. The approximate location of monitoring stations is given in Figure 5 below.

A monitoring station is located at Lot 5 within 15 m of the residence which is the closest to Voyager II Quarry. Two other monitoring stations are maintained to take into account property access issues. If access is available to Lot 3, a monitor is located at the station that is within 15 m of the residence within Lot 3; otherwise, a monitoring station within a paddock at Lot 5 is used that is close to the residence of Lot 4, Horton Road.

Vibration and air overpressure are measured are monitored at a minimum of two locations for each blast.

Monitoring Station Description.

At each monitoring station a triaxial vibration sensor is mounted by way of two bolts on top of a concrete pad that is between about 200 and 400mm diameter, and extends into the ground for up to about 1 metre (see Figure 4 below). The surface of the concrete pad is flush with the ground surface. The concrete column was formed using a rapid set concrete and it has a estimated strength of about 15 MPa. Typically, the concrete column to which the triaxial vibration monitoring transducer is attached can be expected to have a mass of approximately 40 kg. The orientation of the axis of individual geophones that make up the triaxial sensor are constant for all blast measurements.

Blast induced air overpressure is monitored at the same locations as vibration. The sensor used to monitor airblast is tripod mounted, and located at approximately 1.2 m above the ground level.

Figure 4: Vibration Monitoring Pad Near Lot 5 Horton Road
5.1.2 Monitoring Equipment

Blast induced ground vibration is monitored using equipment compliant with AS2187.2 - 2006. Blast induced vibration (peak particle velocity in mm/s) are measured using a standard triaxial geophone with a frequency bandwidth of 4.5Hz to 500Hz.

Blast overpressure are measured using a linear weighted microphone with a frequency bandwidth of 2 Hz to 500 Hz recorded as dB\text{L}_{peak} respectively. Air overpressure is measured in accordance with the requirements of Environmental Protection (Noise) Regulations 1997 (see Section 2.1.1 above)

All measuring instruments are owned and operated by the specialist blast contractor. As required, monitoring equipment is re-calibrated on an annual basis.

The vibration monitor is triggered by a preset vibration threshold. Trigger thresholds are selected on a blast by blast basis to take account of the location of the monitor relative to the blast, background noise and the blast design. Monitor sampling frequency is centred at 500Hz and the sample duration may be adjusted to account for the location of the blast relative to that of the monitor (in order to capture the entire blast induced vibration waveform).

Monitoring results are saved to instrument memory at the time that the monitor is triggered. Immediately after the blast the monitored data is used to generate a report of the blast.
Figure 5.  Approximate Locations of Blast Monitoring Stations *(from Landgate)*

1. Station within BGC premises, but not used – kept in place in case of refusal of entry.
2. Lot 4 Horton Rd. Station nearest blast operations.
3. Alternative station in Paddock, Lot 5 used if access to Station 4 is denied.
4. Lot 3 on Cable Street.
5.1.3 Management of Blast Induced Air Overpressure

BGC Voyager II Quarry manages blast induced air overpressure by:

1. Advising neighbours of the intended blast schedule.
2. Maintaining indigenous vegetation between the Quarry and surrounding areas.
3. Adopting an appropriate stemming design (both material type and stemming height).
4. Adopting an appropriate front row burden.
5. Where possible taking weather conditions (cloud cover, temperature inversions, and wind direction) into account before firing a shot.
6. Monitoring air overpressure at sensitive sites and reviewing the results of monitoring to assess the need for blast design modification.
7. Maintaining a complaints register and investigating complaints.
9. Maximum Instantaneous Charge

5.1.4 Monitoring Results

A vibration and air overpressure monitoring records are generated for each recorded blast. This format of reporting is consistent with the recommendations given in AS2187.2 – 2006. The following information is recorded on each monitoring record:

- Time
- Date
- Monitor Location
- Blast No/Id
- Pattern Type
- Pattern Size (m)
- Designed Tonnage
- Bench Height (m)
- Number of Rows
- Number of Holes
- Blast hole Dia. (mm)
- Stemming (m)
- Sub Drill
- Max. Inst. Charge
- Explosive (Type & Weight)
- Delay Type
- Average Interval
- Duration (ms)
- Comments and Observations, including weather conditions [temp, cloud cover %, and wind direction/speed]
- Monitoring conducted by
- Checked by
- Monitor Serial Number
- Monitor Calibration Date
- Peak Vector Sum Velocity (mm/s)
- Peak Overpressure (dBLpeak)
- Vibration and overpressure traces.
5.1.5 Monitoring Action Outcomes

Should the monitor fail to record information (for example if the vibration is insufficient to trigger the instrument) then an explanation is given on the monitoring record. This would include a statement of trigger levels. The monitoring results are actioned in accordance with AS 2187.2 Table J4.5(A): Acceptable vibration limits for human comfort at sensitive sites are up to 5mm/s for 95% of blasts per annum with a maximum of 10 mm/s (see Table 4 above).

- **Upload of data**: Vibration and air overpressure monitoring results are communicated to the quarry manager as soon as the report has been prepared (immediately after retrieval of the monitor from the monitoring location).

- **Monitor fails to record**: Quarry Manager notified of result. Specialist Blast Contractor to determine reason for no record, and take this into consideration for subsequent blasts.

- **Recorded Vibration 5mm/s or less and Recorded Blast Overpressure 120 dBzpeak or Less**: Quarry Manager notified of result. Report is stored with blast record. No further action required.

- **Recorded vibration greater than 5mm/s and 10 mm/s or less**: Quarry Manager notified of result. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected vibration. Results of review to be taken into account, as appropriate, in future designs.

- **Recorded vibration greater than 10mm/s**: Quarry Manager notified of result. Quarry manager to advise DMP of exceedance of AS requirement. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected vibration. Results of review to be taken into account, as appropriate, in future designs.

- **Recorded Blast Overpressure greater than 120 dBzpeak**: Quarry Manager notified of result. Quarry manager to advise DER of exceedance of Noise Regulations. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected blast overpressure. Quarry Manager to submit report to DER. Results of review to be taken into account, as appropriate, in future designs.

The video for each blast is reviewed by the Specialist Blasting Contractor. If the video shows that there was flyrock then this is to be brought to the attention of the Quarry Manager. A review of the blast design will then be carried out to determine the causes of flyrock. The results of this review will then be incorporated into future blast design and quarry drill and/or blast procedures, as appropriate.

The results of monitoring will form a part of the blast record. The blast record shall be maintained for a minimum of 7 years. Each blast record should include the following information:

- Monitoring results;
- Check form showing BGC Requirements for Post Blast Reports;
- Orica Product Delivery Docket;
- IS Issues Log (Record Issues of Initiating and Packaged Explosives);
- Blast Loading Sheet (with design and actual);
- Blast Summary Data Sheet (plan includes blast layout and initiation sequence);
- Blast Summary Data Sheet (plan includes hole numbers and tie-in);
- Blast Loading Sheet (includes calculated Powder Factor);
- Blast Summary Data Sheet (plan showing holes loaded);
- Blast notification register;
- Blast Summary Data Sheet (plan showing location of blast);
- Orica Service Acknowledgement Form, and;
- Boretrak and laser face profiling records.
5.1.6 Complaints

Complaints associated with blasting are to be referred to the Quarry Manager or nominated person. The complaint shall be entered into the complaints register that is maintained by BGC. The quarry Manager or nominee will advise the complainant of the compliance status of the blast in question. In addition, the Quarry Manager or nominee shall endeavour to work with the complainant to better understand the cause and reaction. The outcome of the interaction with the complainant will be made known to the Specialist Blasting Contractor where practical and appropriate future blast designs will take the outcomes into consideration.

A record of complaints, including actions taken, is incorporated into the annual report that is submitted to the EPA.
6 Stakeholder consultation

A list of major stakeholders is included in Table 8 below

Table 8: Major Stakeholders

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>On-going Liaison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Authority (EPA)</td>
<td>Annual Environmental Report Report non-compliances</td>
</tr>
<tr>
<td>Department of Environmental Regulation (DER)</td>
<td>Periodic reporting as required by Operating License (Pt V of EP Act)</td>
</tr>
<tr>
<td>Department of Mines and Petroleum (DMP)</td>
<td>Compliance with Mines Safety Regulations; Dangerous Goods.; Vibration Compliance</td>
</tr>
<tr>
<td>Shire of Northam</td>
<td>As required by Extractive Industry License. As representative of Shire of Northam residents.</td>
</tr>
<tr>
<td>Shire of Mundaring</td>
<td>As representative of Shire of Mundaring residents.</td>
</tr>
<tr>
<td>Local Residents</td>
<td>Advise blast schedule weekly. Make Blast and Vibration Management Plan Publicly available (via WWW).</td>
</tr>
<tr>
<td>Community Liaison Group (to include Lakes Action Group representation)</td>
<td>Ongoing liaison regarding review and revision of management plans. CLG disbanded as per request by membership. BGC continues to forward information to previous members.</td>
</tr>
</tbody>
</table>
7 Review and Revision

The Voyager II Quarry Blast and Vibration Management Plan is a “live” document. As such it is anticipated that from time to time it will be reviewed and updated to incorporate changes to procedures and systems that are implemented in response to lessons learned. It is anticipated that review and registration will be required as outlined below:

The Blast and Vibration Management Plan will be reviewed annually by the Quarry Manager or nominated person. The annual report to EPA will include comment on the applicability of the current Blast and Vibration Management Plan. The revised Blast and Vibration Management Plan will be made publicly available on http://www.bgc.com.au/.

Table 9: Revision Status

<table>
<thead>
<tr>
<th>Rev No.</th>
<th>Date</th>
<th>Revised By</th>
<th>Revision Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 September 2006</td>
<td>Kevin Holley</td>
<td>First Draft for Review by Rob Holmes of URS.</td>
</tr>
<tr>
<td>2</td>
<td>13 September 2006</td>
<td>Kevin Holley</td>
<td>Second Draft incorporating comment from Rob Holmes. Issued to Paul Berkhout of BGC Voyager II Quarry for Review.</td>
</tr>
<tr>
<td>3</td>
<td>14 September 2006</td>
<td>Kevin Holley</td>
<td>Third Draft incorporating comment from Paul Berkhout of BGC Voyager II Quarry. Issued to Lloyd Acoustics for Peer Review.</td>
</tr>
<tr>
<td>4</td>
<td>25 September 2006</td>
<td>Kevin Holley</td>
<td>Fourth Draft incorporating comment from external peer reviewer – Daniel Lloyd of Lloyd Acoustics.</td>
</tr>
<tr>
<td>5</td>
<td>19 April 2007</td>
<td>Kevin Holley</td>
<td>Final – includes comment from Ben Miles (DEC)</td>
</tr>
<tr>
<td>6</td>
<td>Sep 2011</td>
<td>Holmes Environmental P/L</td>
<td>Approved by P.Yates, BGC Quarries</td>
</tr>
<tr>
<td>7</td>
<td>Jan 2014</td>
<td>Holmes Environmental P/L</td>
<td>Incorporating comments by blast contractor Orica, Approved by P.Yates, BGC Quarries</td>
</tr>
</tbody>
</table>
8 Reporting

The implementation of the Blast and Vibration Management Plan will be reported on annually to the EPA in accordance with the Management Actions Table 10 below. The report will be submitted electronically as a PDF document.

A copy of the Blast and Vibration Management Plan will be made publicly available. This will be achieved by posting the plan on the BGC Quarries WWW site at http://www.bgc.com.au/.

Table 10: Key Management Action Table

<table>
<thead>
<tr>
<th>Ref #</th>
<th>Key Management Action</th>
<th>Target/Objective</th>
<th>Reporting/Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-1</td>
<td>Prepare a Blast and Vibration Management Plan to the requirements of the Minister for the Environment</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA.</td>
</tr>
<tr>
<td>18-2</td>
<td>Implement Blast and Vibration Management Plan to the requirements of the Minister for the Environment</td>
<td>Ministerial Statement 706 Condition 18-1 and 18-3</td>
<td>Annual Reporting to EPA.</td>
</tr>
<tr>
<td>18-3</td>
<td>Review and update the Blast and Vibration Management Plan</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA.</td>
</tr>
<tr>
<td>18-4</td>
<td>Make the Blast and Vibration Management Plan publicly available</td>
<td>Ministerial Statement 706</td>
<td>WWW site</td>
</tr>
</tbody>
</table>